DESIGNING AND DEVELOPING PARAMETERS FOR HUMAN BODY PROTECTORS USED BY INDIAN PARA-MILITARY FORCES DURING RIOTS

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1. INTRODUCTION

Indian armed force or Defense which is the primary force responsible for the security of the country typically consists of Army, Air force and Navy. They come under the authority of Ministry of Defense. They are basically organized for the defense of the country in case of external attack by any another internal disturbance. They are also deployed in cases like internal conflict, humanitarian relief and other tasked jobs issued by the government **[www.1].**

The para-military force lies between the military and the police force. As they fall under the Home Ministry, paramilitary and police forces are given the task of internal law and security. Unlike the police forces, the paramilitary forces get the military like training which equips them for country's defense and internal security. In times of emergencies, they can be deployed under the umbrella of Military forces. So, they play a crucial role in ensuring the security and peace in our country. **Khalidi** (2010), stated that India's armed forces and the police constitute one of the largest security forces around the globe.

1.1 Paramilitary Forces

Sharma and Sharma (2008), defined paramilitary forces as those forces which function like professional military force, but are not regarded as having a same status. The name comes from Greek *para* (which means *beside*) and Latin *miles* (which means *soldier*) **[www.2].** Military dictionary define Paramilitary Forces as "Forces or groups that are distinct from the regular armed forces of country, but resembling them in organization, equipment training or mission" **[www.3].**

India has undergone one of the fastest expansions of paramilitary internal security forces in the world. India's paramilitary strength is widely believed to be over 1.5 million, representing 50

percent of the country's total armed forces. This makes them the second-largest paramilitary force in the world after China **[www.4].**

Para military forces are used in border patrolling, crowd and riot control and to counter – terrorism. These forces play an important role for policing at sea, control and security at airports, official buildings, honorary services, VIP protection, rescue and security of important industrial sites. Para military forces also have an important role in re-establishing law and order in conflict areas, a task which is suited to their training purpose and capabilities.

Sharma and Sharma (2008), explained that Indian paramilitary forces are categorized in twelve organizations under various ministries and state governments. The paramilitary force under Ministry of Defense is Coast Guard Organization. The paramilitary forces under Ministry of home affairs are Assam Rifles (AR), Border Security Force (BSF), Central Industrial Security Force (CISF), Central Reserve Police Force (CRPF), Indo-Tibetan Border Police (ITBP) and Rashtriya Rifle (RR). Paramilitary forces under prime minister's office are National Security Guards and Special Frontier Force. A paramilitary force under ministry of railway is Railway Protection Force (RPF), At the state level there is Home Guard Organization, which is controlled by the state governments. Besides these there are organizations to assist paramilitary forces such as National Cadet Corps and Border Roads Organizations. Over 10 lakh personnel serve in Indian paramilitary forces **[www.5].**

An organization structure of the Indian paramilitary force is presented in **figure 1.**

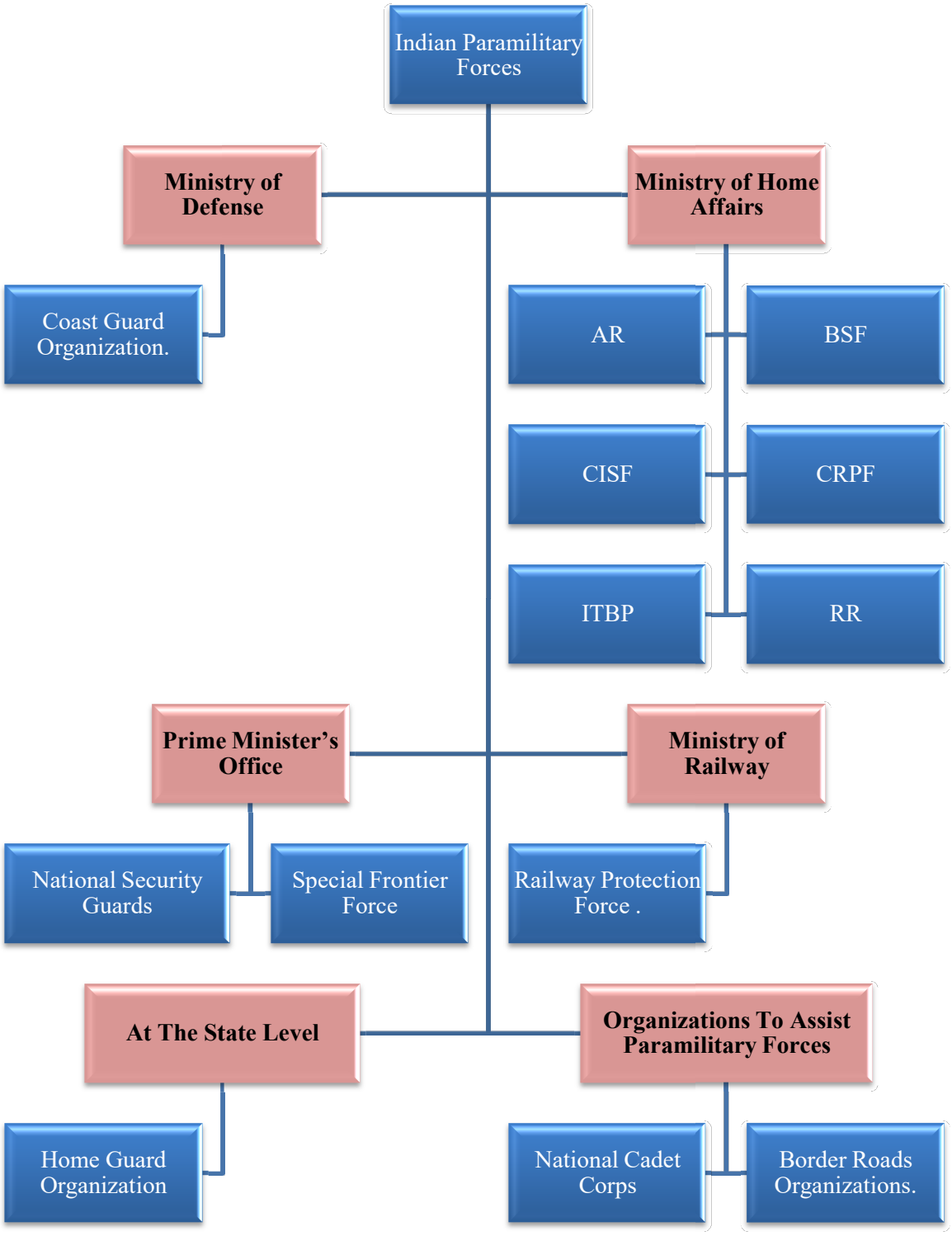


Figure 1 - Organizational Chart of Indian Para Military Forces

1.2 The Quantum of Risks Faced by Indian Paramilitary Forces

Protection of military personnel on land, sea and in the air differs in many respects from protection of civilians. Civilians usually face involuntary accidental situations in the work place which require protective clothing, whereas military personnel in war or in any other situation face many complex hazards which are deliberately aimed at maiming or killing them.

According to **Mallick** (2007), the role of BSF and ITBP are internal security, mostly focusing on counterinsurgency and counterterrorism in the border states. Militancy has existed in many forms mainly in Jammu and Kashmir in the Indian controlled side of the disputed territory. The paramilitary forces which are now deployed in J & K may provide more disciplined force whose military capabilities make them more capable of dealing with all type of violence. The members of armed forces are deployed in extremely dangerous situations. In last few years various stone pelting incidents have taken place. A few are quoted here

- Sep 9, 2017,Tension in Ramganj, Jaipur after mob pelts stones at cops **[www.6].**
- Aug 25, 2017 "Followers of Gurmeet Ram Rahim Singh threw stones at security forces during clashes" **[www.7].**
- Aug 23, 2017 "The agitators tried to stop Kanhaiya Kumar from going to a public meeting and threw stones at the rallyists" **[www.8].**
- Jul 13, 2017 "16 police personnel injured as mob stone-pelt over gangster encounter" **[www.9].**
- Mar 29,2017 "40 CRPF,20 Police personnel injured in stone pelting clash with civilians during Budgam Encounter" **[www.10].**
- Feb 19,2017 "26 soldiers die in J&K in first two months of 2017" **[www.11].**
- Aug 16, 2017 "Pelting of stones by Chinese, Indian troops in Ladakh region surprise officials, One ITBP man sustained head injuries" **[www.12].**

- June 19, 2017 “Stone Throwers Pose A Challenge To Security Forces In Darjeeling” **[www.13].**
- Oct 19, 2016 “Union Minister Babul Supriyo Pelted With Stones In Asansol” **[www.14].**
- September 28, 2016, “Around 2,400 CRPF men were injured in stone pelting incidents in 2016” **[www.15].**
- August 8, 2016 “Kashmir unrest: Over 3,300 security personnel were injured in violence since July” **[www.16].**
- July 21, 2015 “Haryana villagers warned over stone-throwing on Shatabdi Express” **[www.17].**
- January 11, 2011, “Stone pelting in Rajasthan University campus” **[www.18].**
- Dec21, 2010 “60 booked for throwing stones at policemen in Mujjafarnagar” **[www.19].**
- CRPF has faced wrath of the stone pelters, **[www.20].**

As per an article published in e paper of **Hindustan Times** (2017), “ In spite of so many incidents and the occurrence going up, it is interesting to observe that the world’s second largest army is still struggling to equip its soldiers with basic gear that can spell the difference between life and death during operations” **[www.21].** The morale and efficiency of the soldiers and officers are getting affected. They are dedicating their life to the service of the nation and are performing important duties, that too in inhuman living conditions and in the absence of basic facilities. Defense needs to move quickly to fill some vital gaps to enhance the fighting capability of its soldiers and protect them on the battlefield.

Defense forces have raised the concerns about the importance of “body protectors” in riot prone areas, which could improve the potential to save lives during conflicts **[www.21].** Body protector is an integral part of the fighting kit of a wearer as it plays a key role in protecting police or military personnel from enemy threats. The risk of fatality from stones or sharp objects and lathi

assaults is higher for officers who are not wearing body protectors than those wearing body protectors.

1.3 Selection of Protective Clothing

The first step in selecting protective clothing is to determine the hazard, evaluate the potential for exposure and select the degree of protection required. According to **Scott** (2005), the consequences of direct skin contact can range from minor diseases like dermatitis to systemic poisoning and cancer. There are different types of protective clothing and based on their end uses they can be divided into **figure 2.**

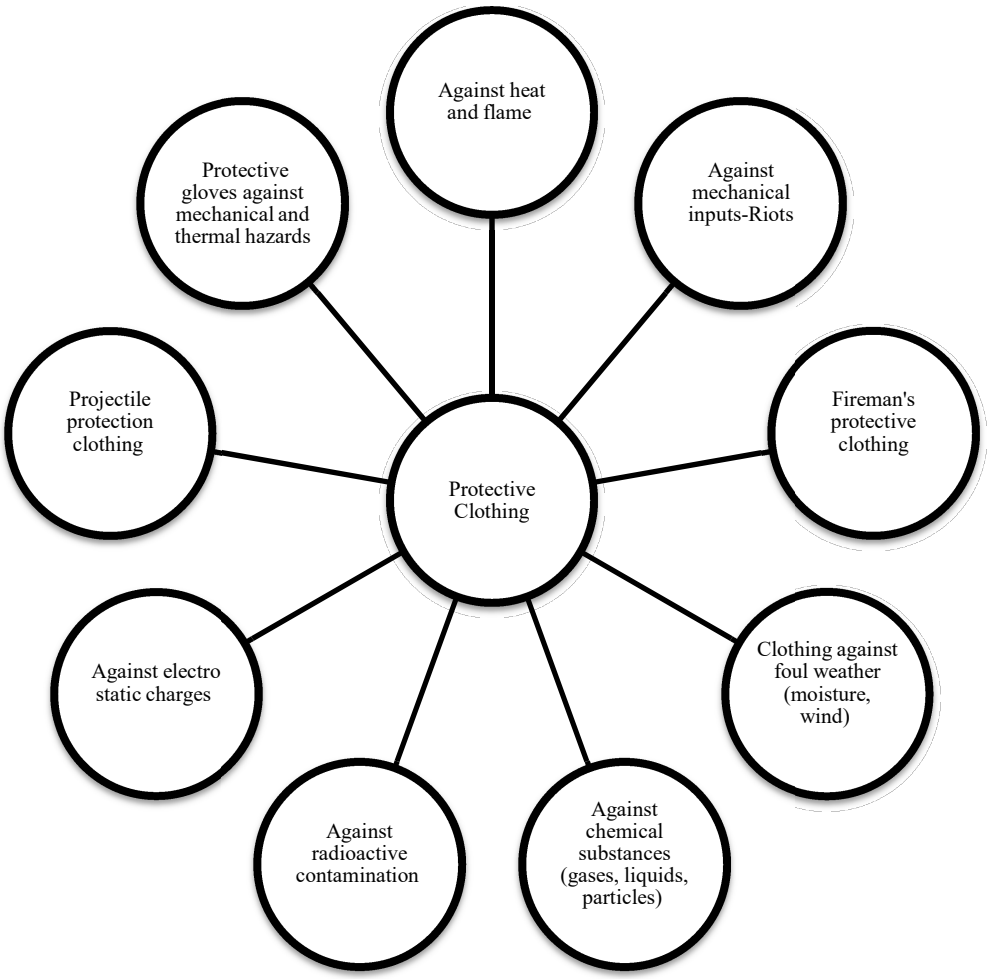

Protective Clothing
Against heat and flame
Against mechanical inputs-Riots
Fireman's protective clothing
Clothing against foul weather (moisture, wind)
Against chemical substances (gases, liquids, particles)
Against radioactive contamination
Against electro static charges
Projectile protection clothing
Protective gloves against mechanical and thermal hazards

Figure 2 - Protective clothing

Protective clothing is an important requirement for police and soldiers especially in recent years when anti-social behavior and global terrorism seem to dominate the headlines. Inadequate safety measures could put frontline professionals at unnecessary risk and cause intolerable injuries or harm. Paramilitary forces face major physical hazard's and such special clothing give protection against the risk of injury that could be caused by strikes from poles or bars, kicks, punches and lathis that may be used against personnel in operations. Such type of protective clothing can also be known as Anti –Riot/ Riot Control Suit or Body protector/ Body Armour. This study is an attempt to develop such protective body protector.

1.4 Body Protectors

History of body armours or protector is very old. Designed primarily to protect against horse kicks or horse falls, the body protector covers most of a rider's torso. They include shoulder protectors, which shield the wearer's collarbone. They work by absorbing the intense energy created by falling off, being kicked or stood on by a horse. Saving themselves from various lives threatening hazard for example war like situation, human being is continuously involved in developing light weight and high quality of body protector. The light weight design and innovative technology that has gone into the body protectors makes it an essential item for soldiers.

Now a days the role of body protector has changed. Today body protector is any defensive covering worn to protect the body from physical attacks such as stone, knife and lathi. **Kumar N** (2013), explained the manufacturing of body protector made of foam (PVC, Nitrile), fire, water and chemical (acid and Alkali) repellent fabrics. The foam is perforated to increase airflow, flexibility and to reduce the weight. Now a days flame retardant foam is also being used for body protectors.

Body protector protects the upper torso however, additional protection is provided by attachable sub components such as shin guard, upper arm, groin guards and others.

Parts of Body protectors

A. **Chest Protector:** Chest protector comprises of front and back .The details are given in **figure 3.**

Figure 3 - Chest Protector
(Image Courtesy :www.22)

1. Shoulder Protectors – Protects the end of the collar bone.
2. Outer Material –Foam which is normally covered by fabric.
3. Inner Material – Most body protectors have 2 levels of foam. This foam is often perforated to reduce the weight, increase flexibility and improve airflow.
4. Weight – The lighter the foam the harder it is when not in use, the heavier the foam the soft it is.
5. Lining – Usually made from a breathable mesh **[www.22].**

B. **Shin guard :** A shin guard or shin pad is a piece of equipment worn in front to protect them from injury **[www.23].**

C. **Upper arm:** Used to cover and protect upper arm.

D. **Shoulder pad** : Padded with foam to protect the shoulder from injury.

E. **Groin guard**: For covering and protecting the waist and groin areas.

F. **Elbow pad, forearm & elbow guard:** It is a complete one part or equipment used to cover and protect arm of the wearer.

G. **Thigh guard:** For protecting the thigh of wearer.

In India the demand of body protector is increasing day by day by paramilitary forces (CRPF, RAF, ITBP, BSF and other groups). In order to cope with J&K, Chandigarh, Rohtak, Darjeeling , West Bengal, Jaipur, Lake Panog and many more situations, where stone throwing is one of the main problem faced by forces such body protectors are desired. In an interview to **"The Tribune"** (2017), **Karwal,** IG, Training of CRPF said that "Such body protector suits have been used in the past by the US armed forces, our soldiers will, too need to be equipped with these, making handling of agitated crowds easier" **[www.24].** Since Indian para military forces need proper body protector. This study has therefore been taken up with an objective to fulfill this need.

1.5 Status of Body Protectors in India

According to **Kumar N** (2013), currently available body protectors in India are manufactured using polycarbonate sheets as shown in **figure -4** (3 mm thickness) and rubber/foam which is inserted (2mm thickness) and stitched with 'coated' flame-retardant fabric. Although, widely accepted by major Indian para-military forces, there is an urgent need to improve the design of the currently used body protectors in our country due to the following reasons:

i) The currently used trauma insert comprise of polycarbonate sheets **(figure 4)** and rubber inserts. This cannot be wrapped around the whole torso area especially with area which moves with the body movement, making them vulnerable to stab attack. This also restricts movement while performing any rigorous activities.

Figure 4- Polycarbonate sheet used in chest protector

(Image Courtesy-www.25)

ii) Owing to the use of polycarbonate sheets and rubber inserts, the currently used trauma inserts are not breathable. This makes them uncomfortable to wear for longer hours especially during summers. [**Kumar N, 2013**]

iii) Various body parts such as neck, armpit and lower abdomen areas in the currently used body protectors in India, are only protected by rubber or soft plastic inserts. This hence provides no protection to the wearer against stab (puncture) attack by screw-driver or spikes.

iv) These body protectors are uncomfortable to wear in a sitting position since the lower edges often presses firmly against the stomach, hip and side of the wearer. Also the top of the shield places pressure on the wearer's throat and chin area..

v) The weight of body protectors cause significant fatigue to the security forces during the working shift.

vi) **Kumar N** (2013) also stated that the currently available body protectors are bulky and not designed as per female para-military forces. e woven fabrics (khaki drill cloth) which are currently being used for the Indian para military forces with outer cover of body protectors are neither 'inherent' flame retardant nor cut or slash resistant. Such flame-retardant 'coated' fabric may be washed out after few washing and this can easily be cut through with sharp edged weapons as shown in **figure 5.**

Figure 5 - Body protector with woven fabric

(Image Courtesy-www.26)

vii) These body protectors are not designed to be worn concealed under outer clothing if required for discreteness. Since the worn body protectors cannot be concealed, the potential attacker is more likely to stab or slash vital areas away from the vest such as the neck or head area.

A glance at the Indian scenario suggests an urgent need to develop appropriate body protectors specifically to be designed for Indian paramilitary forces working in adverse climatic conditions. However, in other countries like USA. Riot Protective Suits include products such as FX1 Flex Force Hard Shell Riot Suit, Riot Robo Suit and others variety of options for varying needs are available. They have fighting, sparring and grappling equipments with hand protection **[www.27].** Details of a few suits available in developed countries are given below.

A. **Riot suit with stab plate:** Upper Body Protection System which is designed to provide substantial protection from blunt force trauma. Built for comfort and fit, the chest, shoulders and hard back shell panels have a modular flex design allowing to fit comfortably with much needed mobility. The chest portion of the suit offers the unique option of adding or removing the aluminum stab plate for additional protection. The back plate offers a raised portion in the center that protects the spine from blunt force injury **[www.27].**

B. **Hard Shell Crowd Control System** : It is the ultimate high-threat level riot control, domestic disturbance and cell extraction suit. The suit is lightweight .The front and back hard shell panels have a modular flex design allowing for all shapes and sizes to fit comfortably. The knee/shin guard has a non-slip surface, which keeps wearer planted in position. Suit is with Antibacterial Protection **[www.27].**

C. **Tactical Riot Suit,** It consists of chest protector, back protector, shoulder protectors, abdomen protectors, groin protectors, and legs as well as arm protectors. There are a total number of 34 modules used in the system to provide the maximum protection with the use of high strength PE fabrics that are incorporated into the system with advanced methodology used in ballistic protection system **[www.28].** Such suits are available in a variety of sizes.

1.6 Need of this Study

According to **Indian defense forum (2017),** now a days "Stone Pelting is the favoured strategy used by the protestors and the terrorists". A handful of men surrounded by hundreds of stone pelters baying for life is as tough, or may be tougher than facing an AK wielding jehadi **[www.29].** In internal riots and clashes, the mob or crowd usually doesn't carry arms and ammunition like guns. They use sharp objects and stones to attack the paramilitary forces which then results in grievous injuries.

In India, to cope up with situations arising in various parts of the country like J&K, Rohtak Jaat agitation and similar episodes, the demand of body protector is increasing day by day for the group of paramilitary forces (CRPF, RAF, ITBP, BSF and other groups). These paramilitary forces have a major role to play in handling such sensitive situations where stone throwing is one of the main problems faced by them. Ideally, this type of operations are the specialty of CRPF troops who have taken up the role of armed counter terrorism in J&K **[www.29]**. This role was earlier with Rapid Action Force (RAF) before the CRPF**.** There are so many incidences reported by the news papers and media, like wise **Times of India** (2016) published "Cops going for full protection" [www.30]. The Central Reserve Police Force has floated tenders in 2016 to procure about 2,000 "full-body protectors" to save its troops from stone pelting in the Valley of Jammu

and Kashmir **[www.30].** Now in 2017, CRPF has demanded 20,000 full body protectors with modification **[www.31].**

As per **Asian Age** (2017), to tackle any riot situation in the national capital the Delhi police are also set to upgrade its anti-riots squad by procuring the latest equipment, "The police has made a notification to procure 7,135 body protectors" **[www.32].** An interview with defense ministry officials suggests that, the need of the hour for the latest body protector includes physical protection from brick-batting, knife and acid attacks to counter Molotov cocktails and fire projectiles being fired at the paramilitary in Jammu and Kashmir. It is stated that while the gear to guard against such riot like protest situations does exist in the CRPF inventory, the recent protests in the Valley have prompted the force to go in for full-body protection **[www.31].**

There are various types of body protectors available and procured by the forces. The fatal injuries caused suggest that the quality of body protectors is not as per the specification provided by the forces. The various designs submitted by the manufacturers are quite inadequate and different too. There is no standardized method or equipment to check the anti- stabbing and anti-impact resistance properties of body protectors. The review states that the body protectors cannot be tested against physical attacks such as stone, knife and lathi. Also current body protectors used by the para-military forces do not provide proper fitting for women. Women's body shape demands different shaping of the materials as per the contour to the body.

With the present status in mind and the review studied, this study will be conducted to modify the current body protectors and develop a new design for men and women personnel. The title of the study emerges as "**Designing and Developing Parameters for Human Body Protectors used in Indian Para-Military Forces During Riots".** The specific objectives framed for the study are given below.

1.7 Objectives of the Study

1. To understand the design and quality requirement of para-military forces for body protectors.
2. To analyze the suitability of present body protectors offered by various manufacturers.
3. To standardize materials used for various parts of the body protector as per the requirement of the Indian para-military forces.
4. To develop indigenous stab and impact resistance testing equipment as well as parameters and standardization of the test method.
5. To design the body protector for men and women paramilitary personnel.
6. To evaluate the effectiveness of the developed body protector in actual field.

1.8 Delimitations of the Study

1. The study will be limited to a sample of 50 personnel form each paramilitary force. Only paramilitary forces would be selected for the present study.
2. The area of sample selection will be limited to Delhi and nearby cantonment areas.
3. The study would be restricted to develop 2 prototypes of body protectors for each male and female.
4. The study would also restrict itself to fabricating prototypes of few tested fabrics only.

2. REVIEW OF LITERATURE

Throughout recorded history, military personnel have used various types of materials to protect themselves from injury during combat. As per **Wilusz (2008)**, protective clothing (or body armour) has progressed from rudimentary leather protection to full-plated suits of armour, and more recently, ballistic cloth.

The purpose of this review is to summarize the existing, scientifically valid researches which have been done to improve the quality of body protectors. All salient articles are presented in this action and a summary **table 1** at the end of this review. It should be noted that many of the studies reviewed focus solely on bullet proof armour without taking into consideration the importance of body protectors.

The literature has been categorized under three headings which are 1.Body Protectors 2. Female body protectors 3.Stab and impact resilient body protectors.

2.1 Body Protectors

The warriors of ancient Rome and medieval Europe covered their torsos with metal plates before going into battles. **Scott, Chen and Chaudhary (2005)**, state that body armour was advanced and mainly in earlier times classified into the following three categories

i. Armour made of leather, fabric, or mixed layers of both, sometimes reinforced by quilting or felt.
ii. Chain mail, made of interwoven rings of iron or steel.
iii. Rigid armour made of metal, horn, wood, plastic, or some other similar tough and resistant material.

However with the advent of more effective weapons like guns and cannons, in the 15th century body armour had to be highly improved against projectiles at high speed. Utilizing traditional body armour seemed impossible as most of them were not reliable enough against firearms. Silk, which was already considered by the Japanese in the medieval period, was not recorded as the first use of soft body armour in the USA until the late 19th century. However, the soft body armour made of silk was only effective against low-velocity bullets travelling at 400 metres per second or less. It was not suitable for the new generation ammunitions travelling at more than 600 metres per second at that time **[www.34].**

Chen and Chaudhry (2005), concluded that in the First World War, various experiments were carried out to develop soft body armour where in linen, tissue, cotton and silk were concerned in the padded neck defense and vests in the UK. The Americans developed bullet-proof body armour by using overlapping steel plates sewn to strong fabric garments against pistol projectiles around the 1920 and 1930. Such body armour could offer good protection but was quite heavy and uncomfortable.

The body armour with effective protection against ammunition fragments known as flak jacket was developed in the Second World War. However, the flak jacket was not good enough against most pistol and rifle threats. In addition, as the flak jacket was sewn with steel plates, the disadvantages in weight and lack of conformability blocked it to be applied widely.

According to **Chen and Chaudhry (2005),** technical breakthrough of body armour research appeared in the 1960s, during which the first ballistic nylon was invented. This newly invented armour which was made of ballistic nylon had reduced weight but improved ballistic protection of the garment.

The revolution in modern body armour generation was brought about by DuPont after the introduction of its new aramid fibre called Kevlar® in 1965. This kind of fibre, which is five times stronger than steel on an equal weight basis, is widely applied in reliable lightweight bullet-

proof body armour **[www.35].** Now a days, such high-strength and high-performance materials in the application of body armour are fairly popular around the world.

2.2 Female Body Armours

Women's participation in the activities needing rigorous and dangerous jobs, which were limited only for men in the past, has increased over the years. More and more women are employed in physically rigorous jobs, like being soldiers and firefighters. These jobs are meaningful and responsible, but many of them are dangerous. Since women are not in the majority, the protective equipment they wear has not been developed for their use. Most manufacturers design the protective equipment for specific danger and not for the wearer.

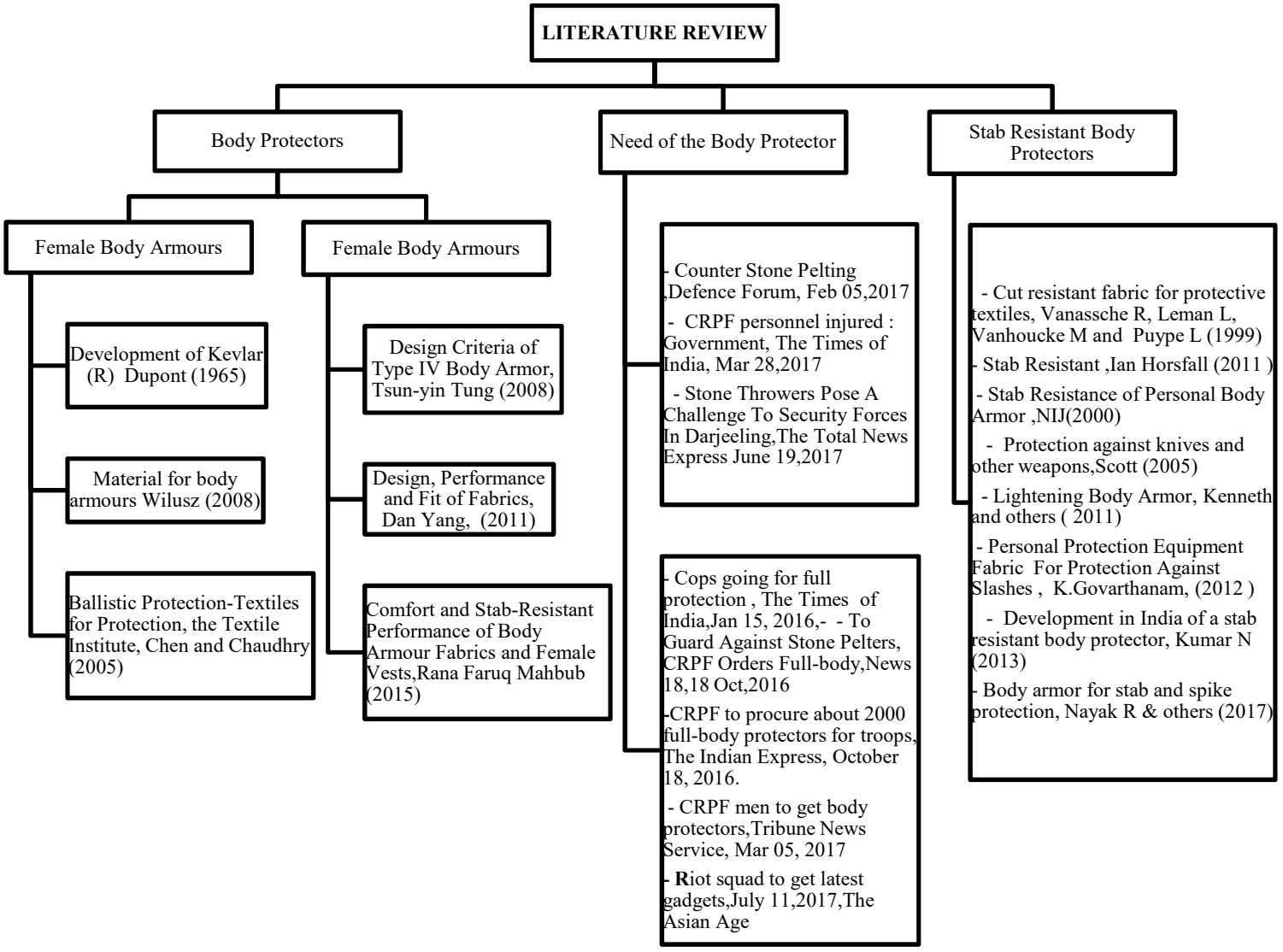
Whatever work which has been done on impact resilient body protector is only done in the field of sports specifically Polo **[www.33]** and Taekwondo. According to **Duygu (2016),** to develop technical skills and improve the performance of taekwondo athletes' an electronic body protectors is used. Because these sports are gender specific, so in these fields female body protector have been designed and developed. No such effort has been carried on paramilitary forces. Very few details of research and design of gender specific have been found. **Tsun-yin Tung (2008), Dan Yang (2011)** and **Rana Faruq Mahbub (2015)** worked on female body amours (bullet proof).
A snapshot of literature review on body protectors done by various researchers is tabulated in **table 1.** However, no work has been found to be done in the field of female body protectors. List of work done by various researchers is presented in **table 2.**

2.3 Stab and Impact Resistant Body Protectors

Number of epidemiological studies have shown great improvements in bullet proof armors with stab and slash resistant, but no significant amount of work has been done on stab resistance or

impact resilient body protectors. R**oger Vanassche, Luc Leman, Marc Vanhoucke and Lode Puype (1999)**, worked on cut resistant fabrics for protective textiles. They developed and patented a fabric comprising elongated steel elements. This fabric is proposed to be used to provide cut-resistance or reinforcement for protective textiles.

Ian Horsfall (**2011),** suggested the simplest method of providing stab resistant clothing by using rigid plates of metal or composite. Such materials are sufficiently hard to defeat knives by resistance to indentation and to present a large resistance to further penetration. **National Institute of Justice**, **Police Scientific Development Branch (U.K), National Institute of Standards and Technology (U.S.A) (2000)[www.36],** have developed a standard to establish a minimum performance requirements and methods of test for the stab resistance personnel body armor intended to protect the torso against slash and stab threats. **Govarthanam (2012),** also suggested three fabric combinations of Kevlar on knitted fabrics against slash and stabs for personnel protective clothing. **Kenneth and others (2011) [www.37],** also worked on light weight body armours and suggested various combinations of armour materials including ceramics, steel plates and composites. **Nayak, Crouch and Kanesalingam (2017)**, discussed the stab and spike protection for body armour with the use of new fibers, shear thickening fluids and nano-materials.


LITERATURE REVIEW
Body Protectors
Need of the Body Protector
Stab Resistant Body Protectors
Female Body Armours
Female Body Armours
Development of Kevlar (R) Dupont (1965)
Material for body armours Wilusz (2008)
Ballistic Protection-Textiles for Protection, the Textile Institute, Chen and Chaudhry (2005)
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- Cut resistant fabric for protective textiles, Vanassche R, Leman L, Vanhoucke M and Puype L (1999)
- Stab Resistant ,Ian Horsfall (2011)
- Stab Resistance of Personal Body Armor ,NIJ(2000)
- Protection against knives and other weapons,Scott (2005)
- Lightening Body Armor, Kenneth and others (2011)
- Personal Protection Equipment Fabric For Protection Against Slashes , K.Govarthanam, (2012)
- Development in India of a stab resistant body protector, Kumar N (2013)
- Body armor for stab and spike protection, Nayak R & others (2017)

Table 1 - Snapshot of Literature Review on Body protector

Tabular Summary of Literature Review		Content							Research Approach			
		Body Armour				Need of body protector		Stab and Impact resistant body protector				
		Male		Female								
Sr. No.	Paper Author	Material	Comfort	Design	Comfort	Causalities	Demand		Descriptive	Conceptual	Empirical	Scientific
1.	Chen and Chaudhry (2005)	✓	✓							✓		
2.	Dan Yang, (2011)			✓								
3.	Defense Forum (Feb 05,2017)					✓						
4.	Duong Tu Tien (2011)			✓								✓
5.	Dupont (1965)	✓										
6.	Govarthanam (2012)							✓				
7.	Horsfall (2011)							✓				
8.	Kenneth ,and others (2011)							✓				
9.	Khalidi, Omar (2010)						✓					
10.	Kumar N (2014)								✓		✓	
11.	Kumar, Arun (2013)						✓					
12.	Mahbub (2015)				✓	✓						
13.	National Institute of Justice (2000)							✓		✓		
14.	Nayak, Crouch and Sinnappoo Kanesalingam (2017)							✓				
15.	News 18 (18 Oct,2016)							✓				
16.	Scott (2005)											
17.	The Asian Age (July 11,2017)						✓					
18.	The Indian Express, (October 18, 2016)						✓					

Table 2 - Summary of Literature Review

Tabular Summary of Literature Review		Content							Research Approach			
		Body Armour				Need of body protector		Stab and Impact resistant body protector				
		Male		Female								
Sr. No.	Paper Author	Material	Comfort	Design	Comfort	Causalities	Demand		Descriptive	Conceptual	Empirical	Scientific
19.	The Times of India (Jan 15, 2016)						✓					
20.	The Times of India (Mar 28,2017)					✓						
21.	The Total News Express (June 19,2017)					✓						
22.	Tribune News Service (Mar 05, 2017)						✓					
23.	Tsun-yin Tung (2008)			✓								
24.	Vanassche R, Leman L, Vanhoucke M and others (1999)								✓			
25.	Wilusz (2008)	✓										✓

3. RESEARCH METHODOLOGY

Research methodology is a way to systematically solve the research problem. The present study would be conducted in 5 phases as shown in **figure 6.**

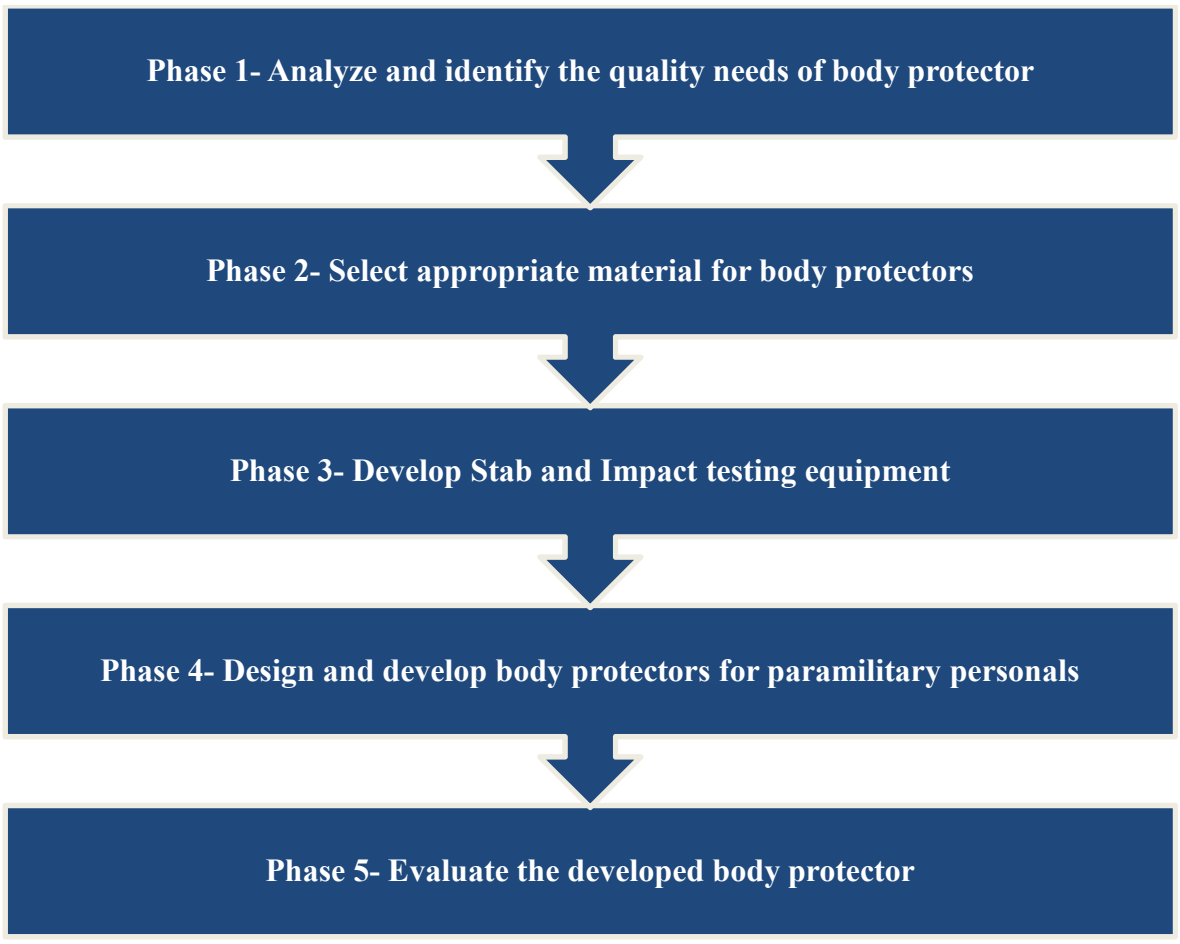
Phase 1- Analyze and identify the quality needs of body protector
Phase 2- Select appropriate material for body protectors
Phase 3- Develop Stab and Impact testing equipment
Phase 4- Design and develop body protectors for paramilitary personals
Phase 5- Evaluate the developed body protector

Figure 6 - Phases in the present study

3.1 Phase -1 Analyze and Identify the Quality Needs of Body Protector

The nature of operations dealt by the forces is varied and hence they face significant challenges. Individuals in military rely on safety clothing for protection against riot conditions, bodily injuries, and physical attacks. Badly designed protective clothing can truly impose real constraints

on human body movements. When considering soldier, the primary concern with protective clothing is undoubtedly parallel to comfort.

The present study is planned to develop a comfortable body protector for male and female soldiers which will neither hinder their movement nor obstruct actions and will also give them protection. To achieve this goal it is important to analyze and identify the prevailing status of the quality of body protectors in India. For understanding the needs, data will be collected from various sources using appropriate tools. The details of target group to be selected and tools used for this objective are highlighted in **table 3.**

This phase is mainly planned to identify the limitations of the existing body protector in terms of comfort, fitting, stab and impact resistance. The research design adopted for this phase is elaborated in **figure 7.**

Methodology, Target groups and Tools		
Objectives	**Target Group**	**Proposed Tools / Methodology**
1. Identification and analysis of quality requirement of body protector	• Para military personnel • Senior officers • Procuring officers • Tendering bodies • Manufacturers	• Questionnaire • Observation Schedule • Structured Interview
2. Samples of body protector	• Paramilitary forces • Manufacturers • Open Market	• Survey • Sample selection and collection • Purchase of items

Table 3 – Methodology, target groups and tools

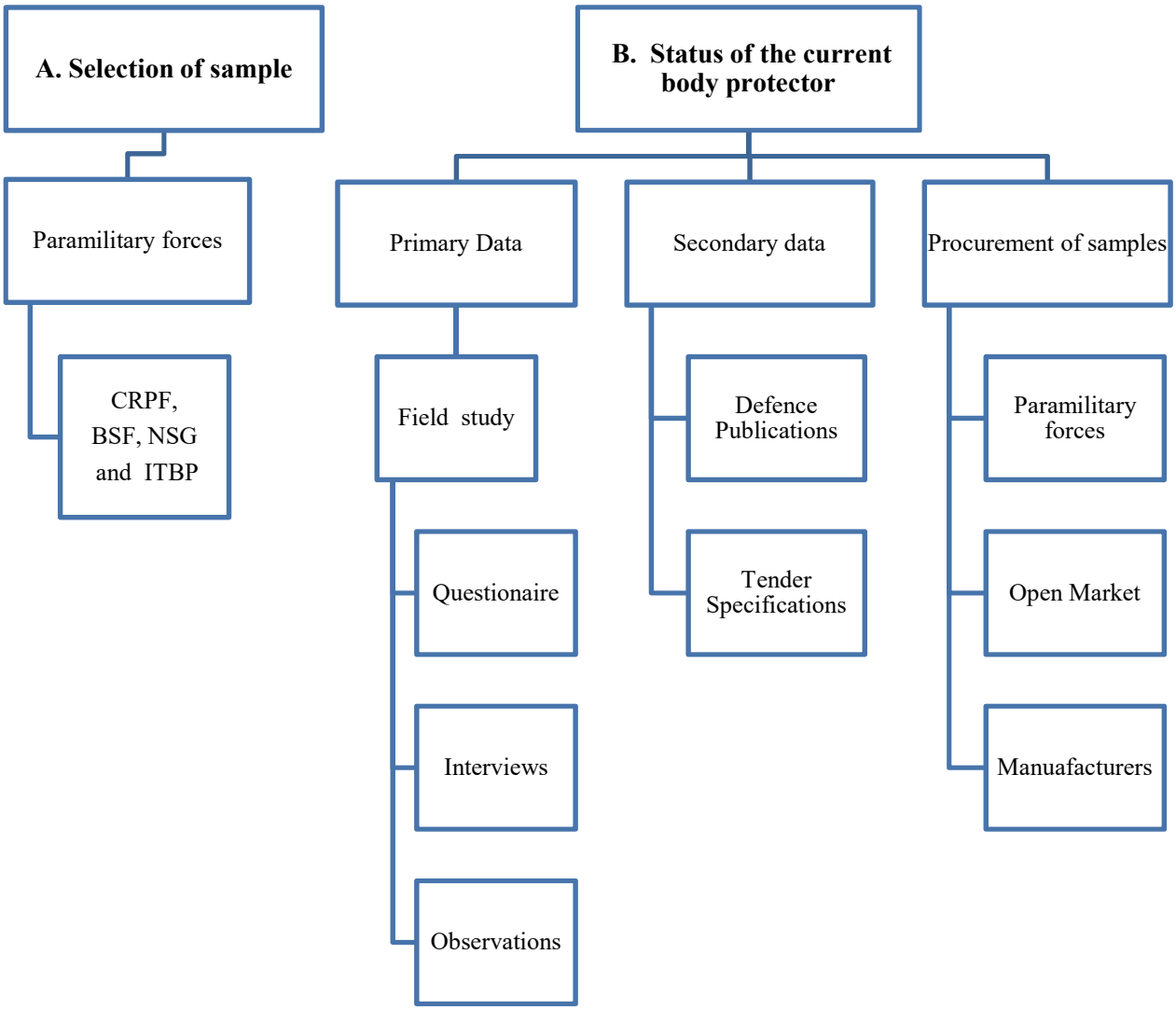

Figure 7 - Steps for Phase –I

- **Selection of sample**

Body protectors have different roles in various sports like ice hockey, horse riding, other sports, occupational activities and paramilitary forces. Present study will be conducted on Para military

forces because paramilitary forces face the risk of serious injury or fatal wounding, while carrying out their duties. The risk of fatality from stones/sharp objects and 'lathi' assaults is high in their occupation.

For the present study among the paramilitary forces, personnel from CRPF, BSF, NSG and ITBP who are mainly dealing with the riot control situations would be selected.

Sample size: For the present study total 50 personnel (male and female) from each force (CRPF, BSF, NSG and ITBP) would be selected.

- **Status of available body protectors**

A range of tools will be used to collect the required information. For the present study self designed questionnaire, observation schedule and group interviews would be used for collecting the data.

A pilot study will be conducted with a few of the para military force personnel in order to design the tools and understand the quality of the current body protector they are using. Thereafter a self designed questionnaire as well as observation schedule will be used for gathering information related to present status. The questionnaire would not only asses the quality and appropriateness of body protectors but also would determine the risk assessment and comfort performance provided in current body protectors used by the Indian paramilitary troops. Group interview techniques would also be used to gather the information wherever desired.

Samples of the available protective body protectors from manufacturers, paramilitary forces and open market would be collected and observed to review the design, sizing system and quality of product in use for the Indian paramilitary forces.

For the present study samples of body protector will be also collected from para military forces. Indian body protector manufacturers who apply for tenders or who finally provide the products will also be contacted for the procurement of such samples. Shops dealing with defense products will be visited for procuring the latest designs and style of body protector in India. Information on body protectors from different sources like defense magazines, Government of India Textile Ministry Reports, newspapers and other related private and public reports would be explored. An analysis of all the collected information from various resources regarding body protector would be complied in order to identify the desired modification and needs of the target group.

3.2 Phase 2- Selection of Appropriate Material for Body Protectors

Protection and comfort are significant aspects for body protector. Appropriate material selection plays very important role in quality of body protector. In the present study the information analyzed from the first phase will be utilized to design body protector. The details of this phase are given in **figure 8 and figure 9.**

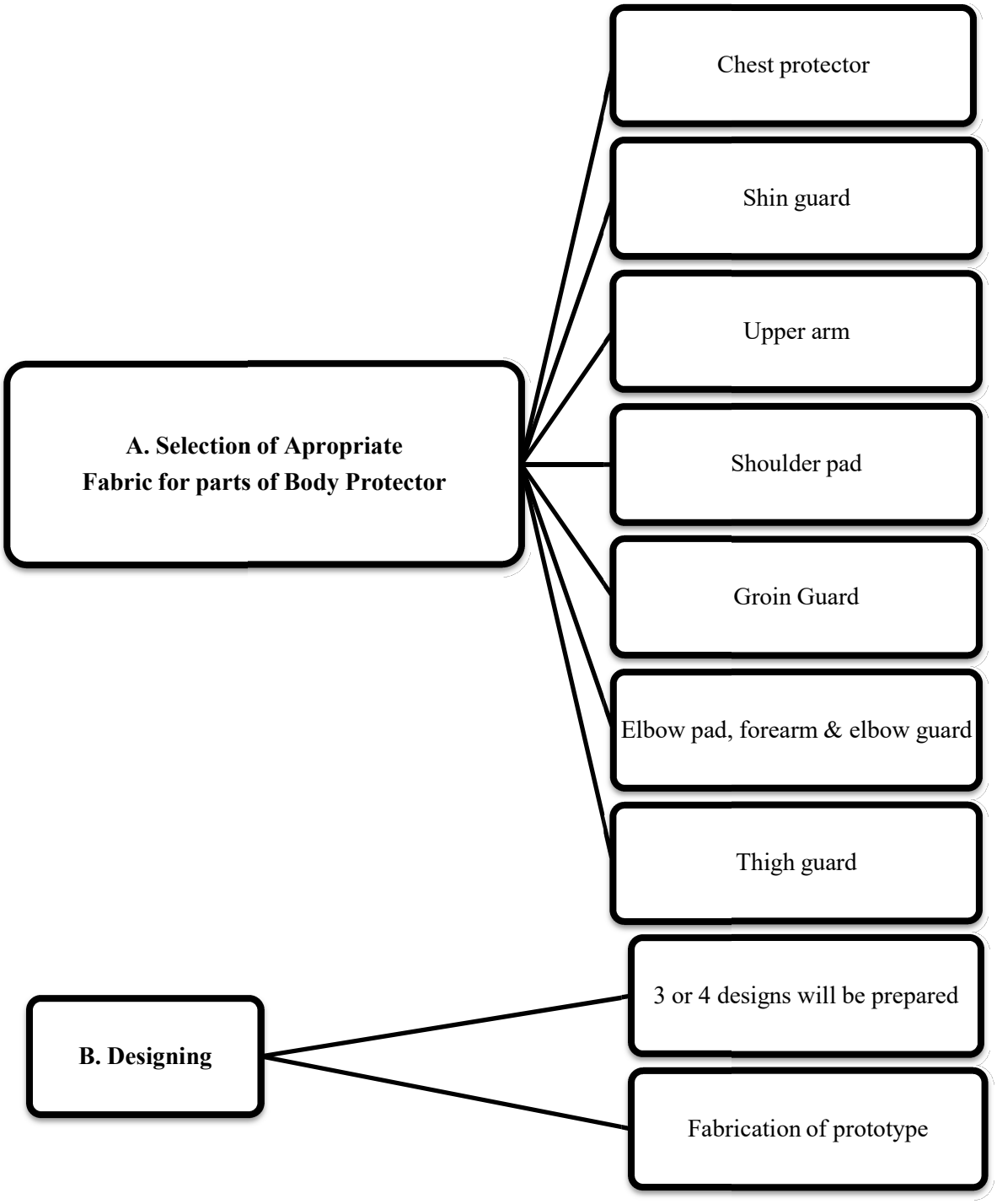

Figure 8 - Steps for Phase –II

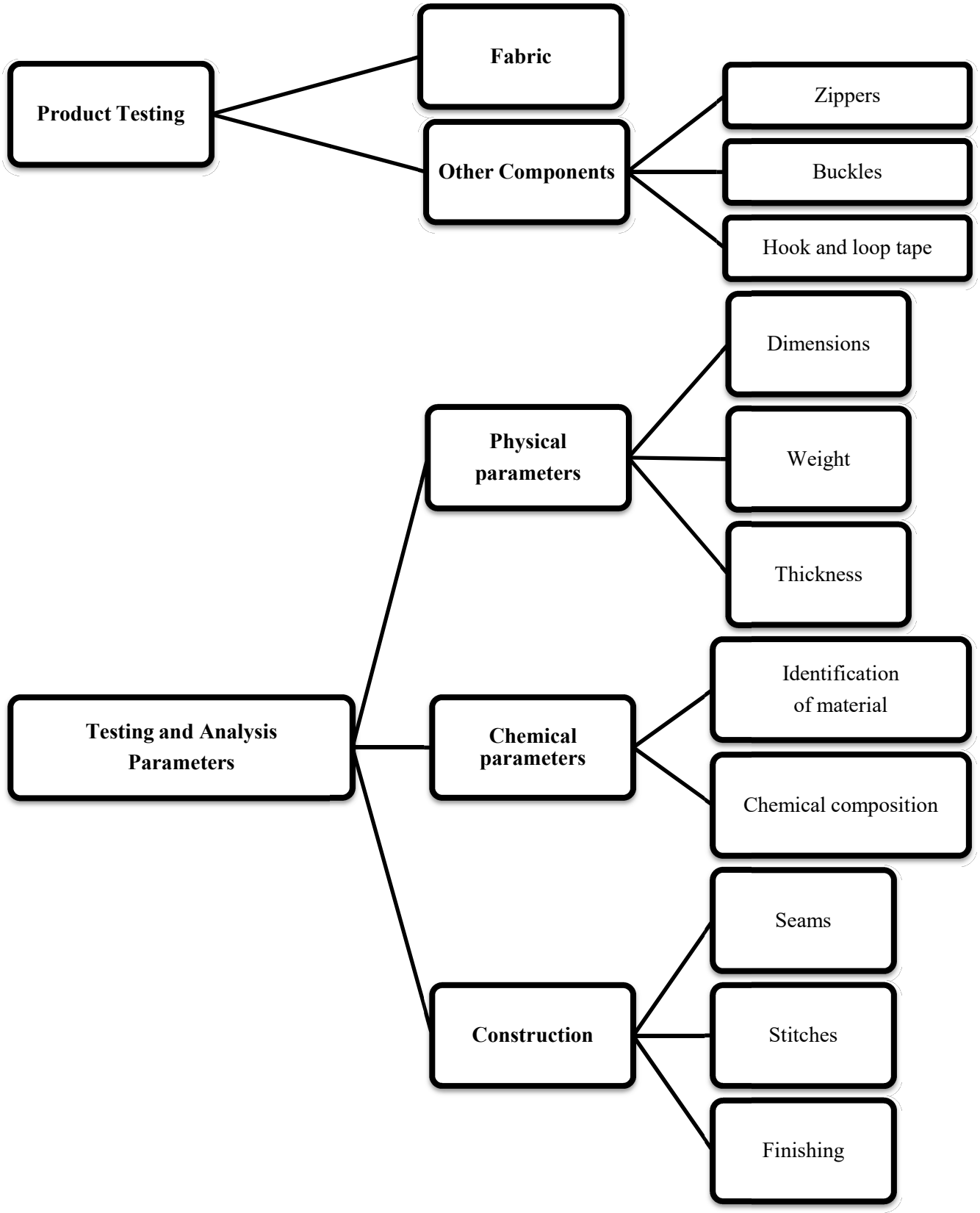

Figure 9 - Steps for selection of products

- **Selection of material used for various parts of body protector**

Each and every part of the body protector needs to be tested as per the requirement of the Indian paramilitary forces. Since type of material plays an important role to protect soldiers from stab and impact threat, it is essential to select the right type of material. Body armour standards require that an impact should be stopped. As stated by **Kumar N (2013)** "The penetration depth into a backing material to the armour should not exceed 1.73 inches. If penetration depth exceeds this value, a wearer can acquire serious blunt trauma". Therefore, the demand for substantial improvement in the performance-to-weight ratio of body armour as well as the performance-to-thickness ratio is very high.

In this phase, various available materials and their combinations will be analyzed and out of those the right type of material which includes fabric and fasteners will be selected after suitable testing. Accessories and fasteners will be tested for mechanical tests. Appropriate and most suitable material as well as their combinations would be selected for preparing each part of the body protector.

3.3 Phase 3- Develop Stab and Impact Testing Equipment

Body protectors have traditionally been designed with the principal purpose of providing protection to the wearer against horse falls **[www.33].** For the Indian paramilitary forces, body protector should protect the wearer against sharp objects like knife, daggers, stabs, petrol bombs and stones as well as lathis. Anti stab resistant body protector should resist pointed and sharp object penetration or slashing.

As the main aim of body protector is to protect human being from various hazards like stabbing and impact of various objects like stones, it is required to test body protectors prior to use in the laboratory for these hazards. To test body protector for these hazards, there is a need of an

instrument which can test stab and impact protection ability of body protector. At present such type of instrument is not available in India to test as per various International standards like **VPAM KDIW 2004** and NIJ **Standard–0115.00**. Non availability of such instrument caused scrapping of tender for procurement of body protectors for paramilitary forces like Rapid Action Force (RAF), CRPF **[www.34]**. There is a demand from these forces that such instrument should be procured at the earliest so that the body protector can be procured through tender process. Hence in the present study, in order to fulfill the evaluation of selected material and to evaluate the functionality of the designed body protectors, an instrument for testing stab and impact resistance property of body protector will be developed as per the International standards.

3.4 Phase 4- Design and Develop Body Protectors for Paramilitary Personnel

Initial interactions suggest that the users of present body protector is reluctant to wear an uncomfortable protective vest **[www.35].** CRPF officials have also asked the Indian manufacturers to modify body protectors for their troops **[www.35].** The primary reason stated for improvement is its high weight which causes discomfort to the wearer.

Therefore while designing body protector, the interaction between the protective vest and the body is an important factor that needs to be considered. This study thus intends to explore the great potential for some traditional textile fibers / fabrics to be properly utilized in developing new designs and engineer body protectors for the Indian para military forces.

The specific requirements of protective properties of a person's professional clothing differ significantly since the hazards that the wearer are exposed are different in each job. To enable the activity to be successful, the developed design needs to maximize protection and minimize the risk. Hence in this study 3 to 4 designs of body protectors would be developed for males and females. In order to be acceptable to the user, the designed body protector would include

functional elements, structural design elements and aesthetic considerations besides the important subjective element of comfort.

Under this phase various designs of body protector will be fabricated as per the requirement of men and women inducted as paramilitary personnel. The designed body protectors will be tested for anti stabbing and impact resistance before being finalized. The steps to be followed for this phase are highlighted in **figure -10**

Figure 10 - Steps for Phase –IV

3.5 Phase 5- Evaluate the Developed Body Protector

Testing a developed prototype is a very important part of the design and manufacturing. Testing and evaluation, simply confirms that the product will work as it is supposed to be. It would also suggest if it needs refinement or whether it adheres to the design principle and standards. In general, testing a prototype allows the researcher and end user to assess the viability of the developed prototypes. For testing parameters would be formulated and standardized.

In this phase, the developed body protector will be evaluated by the selected sample. Test to simulate the real attacks or stabs would be conducted. It will be evaluated against all the parameters and standards set in the design phase like resistance to fire, various angles of stabbing and impact test. The designs would be verified and if needed they will be modified after field evaluation of the body protector for fitment and comfort. Since the major thrust of this study is to modify a current body protector for stab and impact resistance, the developed body protector

would be evaluated for all desired parameters like functionality (protection against stabbing and impact), comfort and fit as per gender.

3.6 Statistical Analysis

For the present study following statistical techniques will be used in to analyze the data

- Arithmetic Mean
- Median
- ANOVA

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